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THE GLACIER OF MT. ARAPAHOE, COLORADO

On the fourth day of August 1900, I was one of a party of seven men who ascended Mt. Arapahoe. This mountain is the highest of a small group of peaks on the Continental divide in Colorado. It is situated about latitude 40° 1′ N. and longitude 105° 38′ W.[1] and has an elevation of 13,520 feet above sea level. There are several peaks of nearly equal altitude in the group, but they are so intimately connected that they form practically one mountain. The group is locally known as "The Arapahoes." The peaks, together with their spurs and connecting ridges, nearly encircle a large enclosure in which the north branch of Boulder Creek rises. In the southern part of this enclosure is a well-defined cirque which is partitioned off by a spur extending into the enclosure from the side of the highest peak. This spur forms the north wall of the cirque. Its west and south walls are formed by Arapahoe Peak proper and the peak next south, together with their connecting ridge, which is but little lower than the summit of the peaks. The east wall is formed by a third peak, the summit of which is a few hundred feet lower than the other two and joined to the peak on the south side by a moderately high ridge. The cirque opens toward the northeast by a constricted passage into Boulder Creek valley.

The inner slopes of the cirque are precipitous on all sides. In only a few places can they be climbed in safety. The accompanying photograph, Fig. 1, taken from a high point and looking downward, does not adequately represent the degree of slope. The south wall is, in places, nearly vertical. The naked cliffs rise something like 1000 feet in the clear. But at the southwest and west sides the slopes are such that great masses of snow and ice of unknown depth lie upon them, reaching from the main mass at the bottom of the cirque, to the top of the ridge. The largest of these arms is shown in

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[1] Hayden's atlas of Colorado.

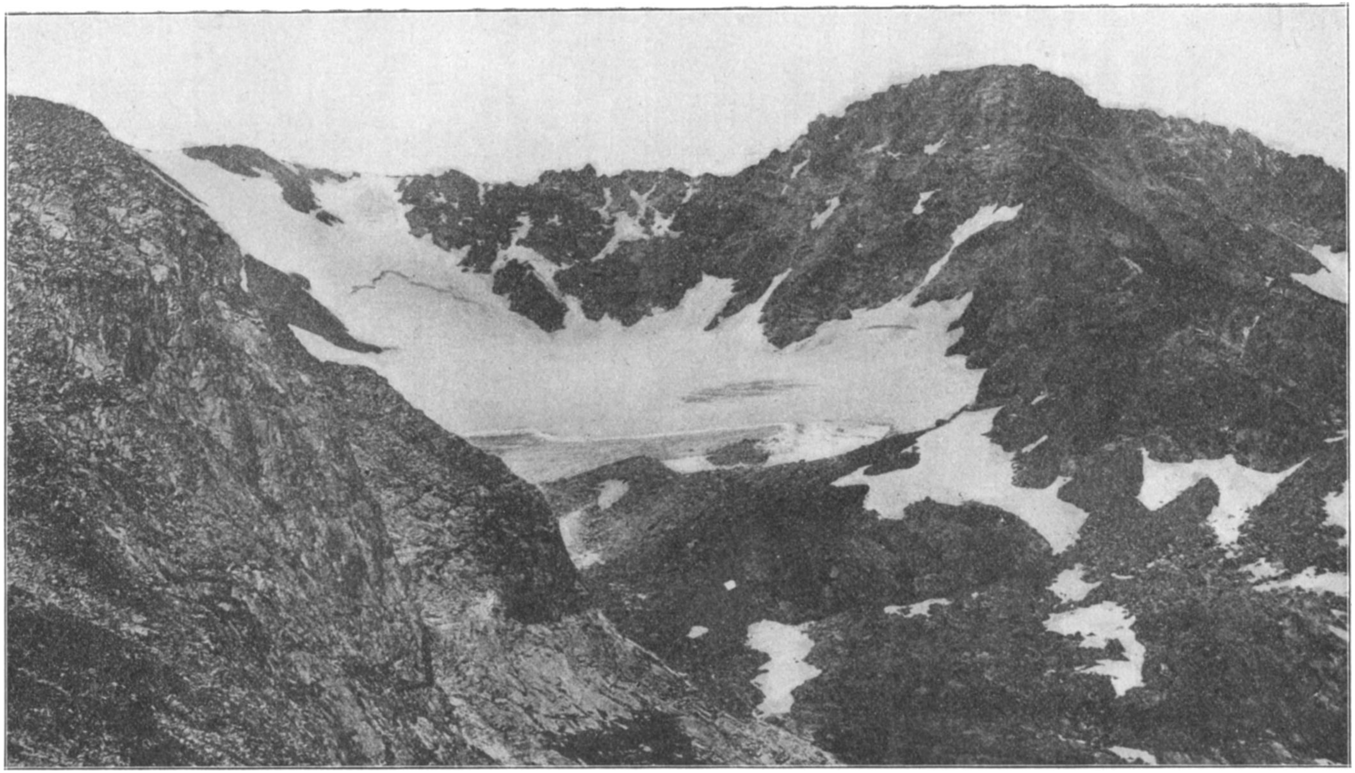

FIG. 1.—View of the Arapahoe glacier from below.

the illustration Fig. 1. The peak with its perpendicular cliffs forming the south wall, together with about one third of the cirque, is cut off from view by the bluff in the foreground. Figure 2 is a near view of this peak showing the upper extremity of one of these arms of snow and ice.

The cirque presents exceptional advantages for the accumulation and preservation of snow and ice:

1. The encircling peaks and ridges are barriers behind which the drifting snow accumulates during the winter. From whatever direction the wind blows, except from the northeast, its velocity is checked by the peaks and ridges forming the walls of the cirque, and the cirque receives its burden of snow. The importance of this mode of accumulation is well illustrated in the long snow drifts which are common along the high ridges throughout the mountains where the winds have dropped their burden in the lee of the crests. In some instances the summer's heat is not sufficient to melt away these drifts even where they lie exposed to the sun on the south side of the ridges.

2. The snow and ice of the cirque are more or less protected from the heat of the sun, by the elevated rim which is highest, and the inner slope steepest, on the south and west sides. On these two sides where the slope is gentle enough to permit it, lie accumulations of snow and ice of unknown thickness, extending from bottom to top of the walls. On the northern side, *i. e.*, the southern slope of the spur, the snow and ice reach but a little way up the side. This may be due in some measure to a difference in the amount of accumulation of snow, but it is certainly due primarily to the greater melting power of the sun on the slope facing southward.

3. The snow and ice of the cirque are also protected by sheltering from the east, south, and west winds. While our party was on one of the peaks overlooking the cirque, a thunder storm from the southwest enveloped the mountain. After the wind had swept the clouds from the southwestern side of the mountain, the cirque remained full of thick mist. The wind which was blowing at a moderately high rate of speed, cut off

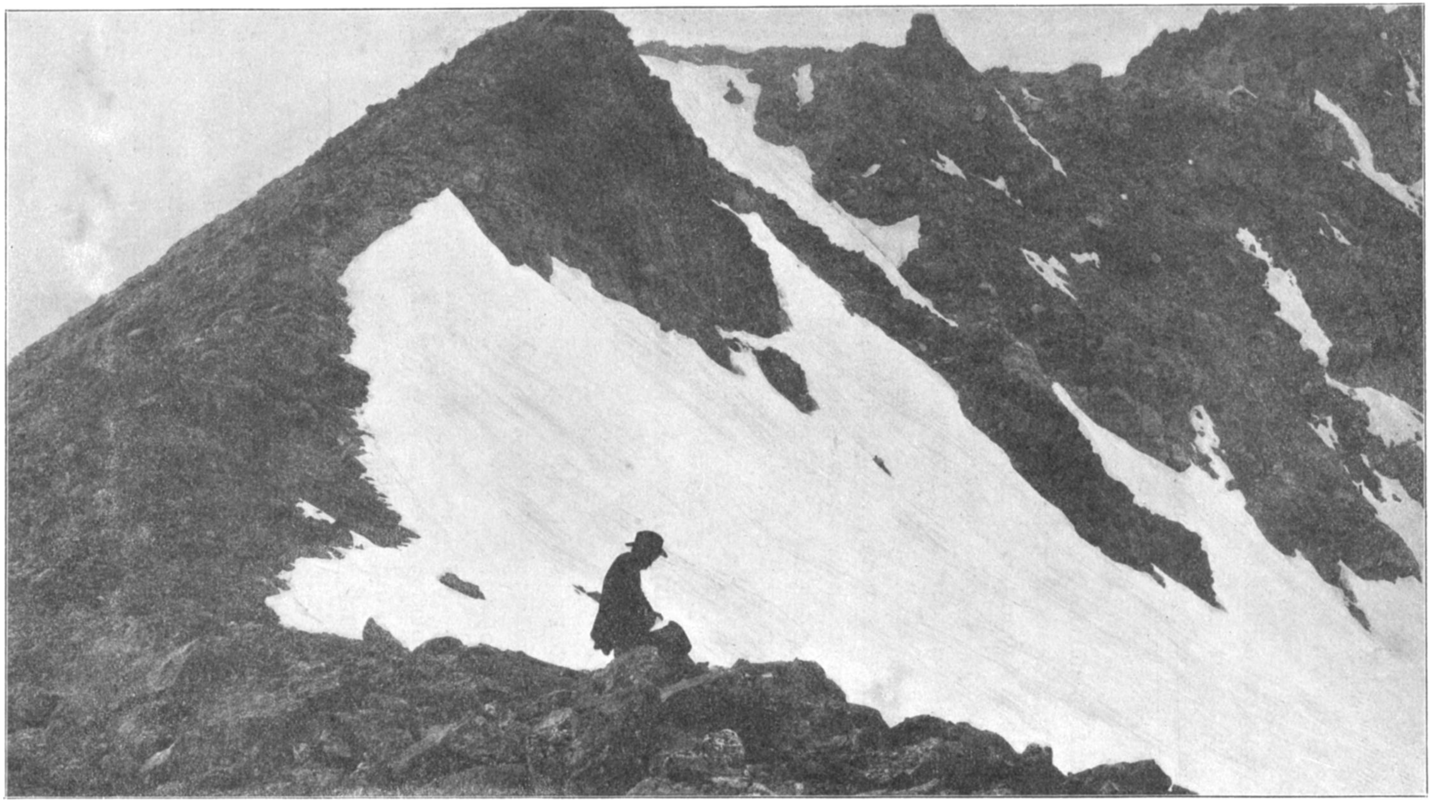

FIG. 2.—The south peak of the Arapahoes, showing the upper extremity of one of the smaller arms of the glacier.

the cloud mass even with the crests of the ridges, and passed completely over the cirque instead of descending into it in any notable measure, and sweeping the mist away. For nearly half an hour after the clouds had been swept away from the windward slope of the mountains, the cirque was more or less obscured by shifting and eddying mists. These were at first parts of the original cloud. Later they were mists formed within the cirque. The latter formed the better index to the action of the winds. From their behavior it was evident that only secondary air currents came in actual contact with the snow and ice of the cirque.

Within the cirque the snow and ice are nearly all collected into two masses. These seem to be essentially independent of each other, and are separated by a ridge of débris. To the east of this ridge is the smaller of the two. To the west of the ridge is the larger—the main mass of snow and ice of the cirque. The larger field was estimated to be nearly two miles wide. Its length seemed to be approximately the same but I was not in a position to make a satisfactory estimate of the length. Its surface is steeply inclined. In several places where the snow and ice extends to the top of the south wall, we measured the inclination of its surface from above as carefully as possible by holding one climbing staff vertically and sighting down the slope with another. The angle thus given showed an inclination of about fifty degrees. At these points the upper edge which had been melted back at its contact with the cliffs, showed a thickness of twenty to forty feet. Over the bottom of the cirque the slope of the surface of the ice is gentle enough for small bowlders from the cliffs above to lodge on it. This gentler slope was somewhat thickly covered in places with stones and small bowlders. No large bowlders were seen on the surface, but below the lower edge of the ice, are great numbers of rock-masses, ten to twenty feet in diameter or even larger. It is probable that the large bowlders gain momentum enough on the steep slopes above to carry them over the gentler slopes and beyond the edge of the ice

The ice is hard and compact to the surface. Bowlders weighing two hundred or three hundred pounds were rolled down the slopes but made little impression on the surface of the ice. A small lake fifteen feet across and four feet deep was found on the surface. Late in the afternoon I found that the ice had softened scarcely enough during the day to prevent me from slipping even on comparatively gentle slopes.

The mountaineers who are familiar with the Arapahoes, had warned us against descending over the ice on account of crevasses. An opening seen about five hundred feet below the top of the ridge and which appears as a broken line in the illustration (Fig. 1) is presumably a crevasse. Others were seen from a distance which were not so well defined. I had no opportunity for close inspection. The mountaineers gave me somewhat careful descriptions of the openings, and told of a man who had been lost presumably in a crevasse. Their search for him resulted in finding nothing but his overcoat. From the descriptions given by these men, and from what I saw of the snow and ice, I am convinced that true crevasses are to be found there.

The stratified nature of the ice is seen along the steep face of its lower edge. Dark bands, probably due to the accumulation of foreign material on the surface during the summer, alternate with lighter bands. Some of the individual bands were traced, with the aid of the field glass, for long distances. Only the uppermost of these bands can be distinguished in the accompanying photograph. This is seen as a light line along the upper edge of the face of the ice, and is due to the whiteness of last winter's snow. On the surface of the ice at the right and a little way back from the edge, is a dark spot where the fresh white snow has been removed from the darkened surface of an older accumulation.

Along the base of the eastern rim of the cirque, a relatively small amount of snow and ice accumulates to form the smaller field. Its tendency to movement indicated by the slope of its surface, is diagonally opposed to that of the greater mass moving from the west and south. Over the surface of this smaller mass I descended for about a mile but discovered no unquestioned evidences of movement of the ice. Between this and the edge of the greater mass to the west, a large ridge of débris has been formed. The ridge is inconspicuous at its inception near the upper end of the smaller ice field, but farther down it increases in size until near the outlet of the cirque it assumes notable proportions. In former times the upper part of this ridge now separating the two snow fields, was probably a medial moraine. But the recession of the ice has changed it into a terminal moraine throughout the greater part of its length. The ridge is crescent shaped and conforms rather closely to the edge of the ice. It has two more or less distinct crests—an outer large one, and an inner small one. Between the smaller crest and the edge of the ice, is a well defined trough.

There is a shallow lake a short distance below the edge of the ice. From an eminence on which I stood looking down upon this lake, I noticed that the current, produced by the stream flowing into it from the ice above, could be plainly traced for several rods by its whiteness which was presumably due to the rock flour derived from the ice above. This was not present in sufficient quantity to attract my attention in the running stream. But the contrast in color as the whitened water of the stream entered the green water of the lake was conspicuous. Closer inspection strengthened the conclusion that the stream carried rock flour.

The size of the ice mass; its great though unknown depth; the steep inclination of its surface; its stratification and crevasses; its terminal moraine; and the rock flour of its stream, all point to the inference that this field of snow and ice constitutes a true glacier.

The valley into which the cirque opens is one of broad bottom and precipitous sides. The side walls are nearly vertical in many places. Its floor is occupied by a chain of lakes interrupted in several places by groups of poorly formed roches moutonnées. Most of the lakes are in rock-hewn basins, but some are formed back of débris dams. One in particular, near the head of the valley, is a beautiful example of the latter. It rests behind a crescent shaped ridge — a comparatively recent terminal moraine. Fragments of terminal moraines extending partly across the valley bottom, occur in several places near the head of the valley.

Résumé.— 1. The exceptional amount of snow and ice in the cirque at Mt. Arapahoe is due to the unusual advantages presented for its accumulation and preservation. These consist (*a*) in trapping the drifting snow, and (*b*) in protecting it from sun and warm winds. 2. Within the cirque are two fields of snow and ice which are essentially independent of each other at the present time. The larger field is estimated to be something like two miles in width and about the same in length. 3. The snow and ice of the larger field constitutes a glacier. This is attested (*a*) by the amount of snow and ice there accumulated, and by the inclination of its surface which varies from about 10° to 50°; (*b*) by its stratification indicated by the banding of the face; and (*c*) by its movement, indicated by the crevasses, the moraines, and the rock flour. 4. This glacier is the survivor of a much larger glacier which formally occupied the upper part of Boulder Creek valley.

WILLIS T. LEE.